National Aeronautics and Space Administration

2014
HEALTH & AIR QUALITY
NASA Earth Science
Applied Sciences Program

www.nasa.gov

Health & Air Quality: 2014 Annual Summary

Table of Contents

http://AppliedSciences.NASA.gov

I. Introduction

The ESD Applied Sciences Program promotes efforts to discover and demonstrate innovative and practical uses of Earth observations. The Program funds applied science research and applications projects to enable near-term uses of Earth observations, formulate new applications, integrate Earth observations and related products in practitioners' decision making, and transfer the applications. The projects are carried out in partnership with public- and private-sector organizations to achieve sustained use and sustained benefits from the Earth observations.

The Applied Sciences Program's applications themes are currently focused on four of the nine Societal Benefit Areas of the interagency U.S. Group on Earth Observations: Health (including Air Quality), Disasters, Ecological Forecasting, and Water Resources.[1] The Program includes climate-related influences and impacts within each of these themes.

The Health & Air Quality Applications area encourages the use of Earth observations in air quality management and public health, particularly involving environmental health and infectious diseases. The area also addresses effects of climate change on air quality and public health to support managers and ultimately people with health-related decision making.

II. Overview of 2014

The past year was a productive one for the Health & Air Quality Applications area, with projects concluding or achieving significant milestones. Projects addressed public health issues such as avian-borne disease, norovirus outbreaks, extreme heat events, and harmful algal blooms. Air quality-related work involved long-range aerosol transport and wildfire emissions, among other air management topics. Nine new projects were selected for funding through a ROSES 2013 solicitation. These projects, with a period of performance of three years, will begin in spring 2015. Current projects in the portfolio exceeded expectations regarding technical performance. In addition, projects received media coverage or substantial praise from stakeholders on the value of the respective applied science.

The Health & Air Quality program continued to support online resources to disseminate important information and data covering health surveillance, the effects of global climate change on public health, and air quality management. The applications area distributed applied research results and led or participated in meetings across the air quality Earth science community, at both the national and international levels.

The following report summarizes a few challenges and many achievements that occurred during 2014. The Health & Air Quality Applications area looks eagerly to the coming years, including future solicitations, continued support for airborne field campaigns, and applications planning for and support of relevant satellite missions.

[1] The nine USGEO SBAs are Agriculture, Climate, Disasters, Ecological Forecasting, Energy, Health, Oceans, Water Resources, and Weather.

III. Major Accomplishments

Some of the notable programmatic achievements this past year include:

A project for monitoring and surveillance of cyanobacterial harmful algal blooms (CyanoHABs) in drinking and recreational water supplies alerted city officials in Toledo, Ohio, to potential contamination of their water supply in August 2014. This project, in partnership with NOAA, utilized MODIS observations to monitor CyanoHABs in western Lake Erie, Saginaw Bay, and several other lakes and estuaries. This information was assimilated into NOAA HAB bulletins which were subscribed to by multiple state and local offices. In addition, the satellite-derived products that were developed for western Lake Erie are being analyzed for their use in other regions (e.g., Chesapeake Bay and inland lakes in Ohio and Florida). This project has established methods to identify environmental thresholds that indicate the potential for cyanobacterial blooms to form or persist, and these data sets are being made available to CDC.

Several projects made significant contributions to decision support for air quality management. For example, a project applied MODIS and OMI observations to enhance the EPA AirNow framework with improved data about the spatial distribution of fine particulate matter. The project developed a satellite data processing system for AirNow that increases the spatial coverage and accuracy of air quality forecasting. The project completed a survey of the socioeconomic and financial benefits of adding NASA satellite data to AirNow using face-to-face interviews and presented its findings in an online publication: *http://www.ctg.albany.edu/projects/pubs?proj=airnow&sub=pubs.*

Environmental Health Perspectives, a publication of the National Institutes of Health, published an article entitled, “Remote-Sensing Applications for Environmental Health Research,” in the October 2014 edition. The article heavily emphasized NASA contributions to the field. The full article can be found at the following link: *http://ehp.niehs.nih.gov/122-A268/*.

The program released a new solicitation in December 2013 as part of NASA Research Opportunities in Space and Earth Sciences (ROSES) 2013. The solicitation invited proposals that a) develop and prove the potential enhancements of an application of specific Earth observations to one or more decision-making activity and b) transfer and enable the adoption of this application by one or more specific end user organizations in a sustainable manner (i.e., without continued NASA financial support post-project). Proposals were due on April 24, the review panel completed deliberations on August 29, and selection letters were sent out on November 14, adding nine new projects to the portfolio. These new projects will begin in spring 2015.

The NASA Air Quality Applied Sciences Team (AQAST, *http://aqast.org*) focuses on exploiting Earth Science data and tools to serve the rapidly evolving needs of U.S. air quality management. Team members conduct individual applied research projects in collaboration with air quality managers, and participate in ad hoc, yearly-competed Tiger Teams for rapid-response applications. AQAST meetings are conducted every six months to review progress and for managers from state, local, and regional air quality

agencies as well as industry, to meet. AQAST action items are identified at these meetings based on the needs expressed by the air quality agencies.

AQAST meetings in 2014 took place in Houston (January), Boston (June), and Atlanta (December). The meetings lasted approximately two and a half days each and have become a major event in the air quality management and applications communities. Each meeting drew about 100 participants. The rising participation of air quality managers has led over the past year to a whole day of each meeting being dedicated to "Air Quality Managers' Sessions" where AQAST members hear from air quality managers about their needs. Discussion panels are a major element of these sessions. All AQAST meeting presentations are posted on the AQAST website.

Other instruments of communication between AQAST members and air quality managers include the AQAST Media Center (*www.aqast-media.org*) and the AQAST Newsletter, which is published every three months. Starting in 2014, the AQAST Newsletter expanded to feature major success stories of AQAST members working with air quality managers (*http://www.aqast-media.org/#!aqast-stories/c1e8l*). The AQAST Twitter account has near 1,600 followers. It promotes new research of the team, connects with air quality management agencies, and offers a mechanism to communicate NASA science related to air quality to the public and stakeholders.

A major highlight was the February 2014 publication of an AQAST special issue of *Environmental Manager*, the trade journal of the Air and Waste Management Association. The issue featured a satellite on its cover with a title stating, "Applying Satellite Data to Air Quality Management: Research conducted by the NASA Air Quality Applied Sciences Team (AQAST) shows that Earth science data are a great potential resource for air quality managers." Another highlight was the publication by AQAST principal investigator (PI) Jack Fishman of the August cover story of the *Bulletin of the American Meteorological Society* entitled, "Growing Understanding: the St. Louis Ozone Garden." Several AQAST PIs contributed articles to the September 2014 DISCOVER-AQ special issue of *Environmental Manager*.

Other specific AQAST highlights during 2014 included:

- Publication in *Atmospheric Environment* of two primers on the use of satellite data for air quality management, one focusing on emissions (Streets et al., 2014) and the other more generally on better understanding the strengths and limitations of satellite data (Duncan et al., 2014). These reviews were Tiger Team AQAST efforts and each involved nine AQAST PIs as coauthors.
- On the 10th anniversary celebration of the *Aura* satellite launch, AQAST PI Bryan Duncan led a NASA Air Quality media campaign that used OMI NO_2 data to convey the message that U.S. air quality has improved by 30-40 percent in the last decade, but further reductions are necessary for all Americans to have healthy air. Several AQAST PIs including Duncan, Russ Dickerson, and Anne Thompson were interviewed by more than 30 news organizations, including CNN, Fox News, and The Weather Channel.

- An AQAST Tiger Team of PIs Arlene Fiore and Daniel Jacob published a paper showing large differences in North American background (NAB) ozone estimates in the global GEOS-Chem and GFDL AM3 models. Evaluation of the base model simulations with space- and ground-based observations indicated value in considering both models as they often bracketed the observations, and biases varied regionally and seasonally. This analysis was of great value for the EPA Integrated Scientific Assessment used in the current reconsideration of the ozone standard.
- AQAST PI Fiore published a paper examining changes in future U.S. ozone air quality resulting from changes in climate, regional precursor emissions, and global methane abundances. Eastern U.S. NOx emission reductions over the past decade were found to have induced a discernible shift in observed ozone seasonal cycles over the Northeast U.S., which is broadly captured by the GFDL CM3 chemistry-climate model. Additional projected decreases in NOx emissions lead to a reversal in the seasonal cycle over the northeastern U.S., with a late-winter, early-spring peak, as observed currently at remote sites. Rising methane can increase the amplitude of this peak and offset the summertime NOx-driven decreases. A warming climate leads to summer increases of a few ppb in the NE U.S. but these changes can be offset with NOx emission controls.
- AQAST Tiger Teams continued to build extraordinary partnerships between AQAST scientists and air quality managers. The biggest of these teams, focusing on air pollution episodes across the eastern U.S., has engaged over 20 air quality managers representing 15 state and federal air quality management agencies. Through monthly phone meetings, all with high levels of participation, the AQAST scientists share recent work, answer questions, and respond to science needs from participating agencies.

IV. Assessment

The most common technical issue in the portfolio in 2014 remained the final transfer of projects to sustainable operations. While some projects have performed admirably in this task, others still faced hurdles in completing this final step. The most common hurdle appeared to be more an issue of partner budget issues than partner capacity; although, two projects saw additional support from their end user organizations during the year. Overall the portfolio exceeded expectations on technical performance.

The portfolio continued to carry a high burden of uncosted funds in 2014. Associates worked diligently with principal investigators to uncover issues at their particular institutions. Many times this appeared to be an issue of “invoice lag” between NASA and the institutions, with costed funds not showing on NASA accounts until long after invoices had been submitted by grantees. However, significant progress was made. The program saw a 72 percent reduction in FY13 uncosted funds by the end of 2014.

Overall, the portfolio had a good track record for remaining on schedule in 2014, with limited no-cost extensions approved based on new opportunities or partner issues.

In general, the portfolio accomplished significant results and accomplishments in all areas in 2014, with a bright outlook for 2015.

V. Project Portfolio

In 2014, the Health & Air Quality portfolio included 11 projects and feasibility studies along with activities of the 19-member Air Quality Applied Sciences Team. The portfolio exceeded expectations on technical performance. In fact, the portfolio had 55 percent of its projects increase by one Application Readiness Level (ARL) in 2014. Twenty-seven percent of projects increased by two or more ARLs. Additionally, nine projects achieved an ARL 7 or higher in 2014. The appendix of this report includes project highlights for 2014.

VI. Program Management

The Health & Air Quality team conducted its last annual review in St. Paul, Minnesota, in 2013. The review consisted of an accounting of results and milestones met over the past year and, if the project was continuing, a look forward to plans for the coming year. Principal investigators also detailed any risks to schedule and/or intended milestones—and a plan on how to mitigate those risks, if any. Project risks could include technical risks/challenges (e.g., loss of satellite during project, significant technical hurdle), operations challenges/risks, management challenges/risks (e.g., partners don't focus on project as promised), or policy challenges/risk. PIs also included information on current budget—including costing data. Presentations from the 2013 review can be found at *http://weather.msfc.nasa.gov/conference/phconference_agenda_sp.html*.

As the vast majority of projects in the portfolio (outside of AQAST) completed their work in 2013 and 2014, it was not considered an efficient use of resources to conduct an annual review with limited attendance in 2014. Planning for the 2015 annual review is currently underway, which will include the first presentations from the nine new projects selected for award in 2014. The meeting is planned for Salt Lake City in May 2015.

Associates and Headquarters program management continued to meet regularly through 2014 to coordinate on costing issues, progress on project metrics, conference and workshop presentations, and project results to be highlighted through web features or other internal and external venues. These discussions were briefed bi-monthly to Applied Sciences leadership at regularly scheduled program reviews.

Associates for Health & Air Quality continue to be Sue Estes (University of Alabama-Huntsville) and Ali Omar (NASA Langley Research Center).

VII. Community Leadership

The applications area presented and led sessions at meetings of the American Thoracic Society, the Air & Waste Management Association, and the American Meteorological Society (AMS). Sessions at the AMS annual meeting in Atlanta were held as part of the Fifth Conference on Environment and Health, of which NASA is a standing committee member. The conference examined how the confluence of the built environment, policies, and the natural environment impact human health. In addition to identifying the

problems, the conference invited speakers to suggest mechanisms for solutions, including policy, Artificial Intelligence, and research-to-operation explorations that further the path of discovery. The 2014 theme was designed to combine scientific inquiry, technological advances, societal implications, and public awareness through the lens of past, current, and future extreme weather and climate. NASA co-chaired the conference, and several investigators from the Health & Air Quality Applications area presented papers.

The *SMAP* Applications Workshop on Health was held in Atlanta in January 2014. The goals of this workshop, held in cooperation with the CDC were to**:** 1) Identify the challenges and needs of communities within CDC (Drought, Hazard, Heat Famine, and Zoonotic) and provide information on the value of soil moisture applications; 2) Incorporate *SMAP* data into the Environmental Public Health Tracking database; and 3) Link SMAP Community to CDC so health related research can leverage expertise data and models from both agencies. Actions from this workshop included: 1) Conduct an Outreach/Awareness and Education meeting at the CDC. This will be a meeting to inform CDC about all NASA data that could be valuable for health research; 2) Conduct a focus meeting that will bring soil moisture data (and value added products) as layers to the CDC's data-tracking program. This effort would include giving a tutorial on how to use soil moisture data from *SMOS* and *SMAP* scaled to the needs of the health community at CDC; and 3) connect the CDC's Research and Analysis Training Program and the Spotlight Program to the NASA Goddard Policy Series as a source for future guest speakers. Presentations from the workshop have been posted at *https://www.signup4.net/public/ap.aspx?EID=SMAP11E&OID=161.*

The AMS Washington Forum (AWF) took place in April 2014, in Washington, D.C. As in prior years, the purpose of the forum was to provide an opportunity for weather, water, and climate enterprise stakeholders to meet with senior federal agency officials and Congressional staff to hear about the status of current programs, learn about new initiatives, discuss issues of interest to the enterprise, and identify business opportunities. The AWF was primarily attended by AMS corporate members, private sector executives, federal agency and laboratory managers, and scientists and university faculty. The theme of the 2014 forum was “Leveraging the Enterprise, Strengthening Our Value to Society.” The program organized a session on Health Connections. The extent of human health risks from extreme weather and climate events depends not just on exposure to these events, but also on the status of the public health and health care systems, built environment, and natural environment, and on the capacity of individuals and communities to understand the risk and avoid, prepare for, cope with, and recover from extreme events. Invited panelists explored how recent scientific understanding of the magnitude and pattern of possible impacts, and of the effectiveness of measures to communicate and manage risks, can inform local to national policy development. Panelists included representatives from EPA, CDC, the Armed Forces Institute for Pathology, and Health Canada.

The American Thoracic Society’s Annual Meeting was held in May 2014 in San Diego. NASA organized and chaired a session entitled “NASA’S Satellites and Their Use in

Studying Air Quality as Related to Wildfires and Dust." This session included presentations from NASA, the University of Arizona, and the National Institute of Aerospace. The session was well attended and had high visibility due to recent wildfires in the San Diego metropolitan area.

The Air and Waste Management Annual Meeting was held in June 2014 in Long Beach, California. The NASA booth/Hyperwall display in the exhibition hall was considered by many to be the highlight of the event. Several NASA scientists and partners presented results via the Hyperwall during session breaks, drawing large crowds. NASA organized two sessions during the meeting, both of which were well attended. Interest in NASA was very high owing to AQAST being the cover story of the February 2014 edition of *Environmental Manager*. Due to the success of this conference, NASA has agreed to an even larger role in organizing the 2015 Annual Meeting in Raleigh.

NASA co-chaired a session at the American Society of Tropical Medicine and Hygiene Annual Meeting in New Orleans in November 2015. The session was entitled, "State of the art of using satellite remote sensing for disease surveillance and outbreak prediction, current limitations, and future promises." The well-attended session explored the utilization of remote sensing for risk characterization and surveillance of vector- and water-borne diseases.

The Second *Suomi-NPP* Applications Workshop took place in November 2014, in Huntsville, Alabama. The workshop was hosted by the University of Alabama in Huntsville and NASA Marshall Space Flight Center, in collaboration with other state and federal entities. The meeting reviewed new products available from the *Suomi-NPP* Science Team and opportunities to use *Suomi-NPP* in support of Applied Sciences focus areas. Reports from the breakout sessions encouraged NASA to accelerate the delivery of *Suomi-NPP* products through the popular NASA LANCE system, improving near real-time access. Nearly 100 attendees provided feedback to the Applied Sciences Program on applications of *Suomi-NPP* data and their community requirements. Presenters of note included Jeff Privette of NOAA's National Climatic Data Center, who highlighted the tremendous growth in the use of satellite products for weather and climate applications, and Chris Elvidge of NOAA's Geophysical Data Center, who demonstrated applications of the VIIRS day-night band for monitoring human settlements and other activities.

The program continued its active participation in the USGCRP Climate Change and Human Health Working Group (CCHHG) in 2014. Through the CCHHG, the program contributed material and authors for the National Climate Assessment and the "Interagency Special Report on the Impacts of Climate Change on Human Health in the United States."

A NASA web feature on AQAST applied research into the health costs of air pollution from agriculture was released in March. An additional NASA web feature on the DISCOVER-AQ and Front Range Air Pollution and Photochemistry Experiment or

FRAPPE airborne missions was released in July. AQAST members were well represented in both missions. The program also saw media coverage of its activities across multiple sources including the *New York Times* and National Public Radio.

VIII. International Activities

The program continued its participation in the GEO Health and Environment Community of Practice (CoP). Program contributions are particularly relevant to GEO tasks HE-01-C1: Air-borne Diseases, Air Quality and Aeroallergens, and HE-01-C3: Vector-borne Diseases. Rifat Hossain of the WHO (Task Coordinator for HE-01) presented at the 2014 GEO Workplan Symposium. Key accomplishments noted in Task HE-01 included 1) a partnership with the Berg-en-dal Group of Cholera Reference Scientists; 2) a meeting of the Health CoP in Washington, D.C. (July 2013, sponsored by NASA) where Rifat Hossain, WHO; Kym Watson, Fraunhofer Institute Germany; Ramesh Dhiman, India; and Cecile Vignole, CNES were named the new chairs of the CoP; 3) launch of the Cholera Early Warning System at the GEO X Plenary; and 4) dissemination of EO2HEAVEN results to the OGC Domain Working Group on Health. Hossain also discussed the need for stronger coordination with other SBAs, particularly the Water SBA. Additionally, he noted strong linkages between the Health CoP and the U.N. Sustainability Development Goals and Millennium Development Goals. However, variances in model assumptions and uncertainties, as well as the lack of best practices in assessment of data impacts, remain great challenges. While no meeting of the Health CoP occurred in 2014, the next meeting is planned for 2015.

The program presented at the WHO's first Consultation Meeting on the "Use of Satellite Remote Sensing Data for Estimating Exposure to Air Pollution" on January 30. This meeting led to a workshop on "Space Technology for Socio-Economic Benefits" at the 24th United Nations/International Astronautical Federation (IAF) Congress in Toronto, Canada, on September 26-28. Global Health was one of two foci for the workshop. The program presented an overview of NASA Health and Air Quality Applications. Multiple recommendations were made to the UN by the workshop, including encouraging "Global Health" as a focus of the 2015 Committee on the Peaceful Uses of Outer Space Meeting (COPOUS), as well as the 2015 IAF. Other recommendations were focused on capacity building, community engagement, and the development of topically-focused expert teams. Productive side discussions were also held, particularly with CSA and Public Health Canada. This workshop led to NASA representation on the COPOUS Focus Group on Global Health.

The program collaborated with the World Health Organization (WHO) and NASA SERVIR in fall 2014 to investigate the viability of extending results from previous projects on hemorrhagic fever risk characterization in sub-Saharan Africa to the ongoing Ebola virus outbreak in West Africa. This effort is continuing into 2015.

A feature entitled "Climate Conditions Help Forecast Meningitis Outbreaks" was published in the March 2014 edition of *Astrobiology Magazine*. The project highlighted was partially funded by the NASA Applied Sciences Program. The project, in

cooperation with the WHO, GISS, and Columbia University, demonstrated how wind and dust conditions in Sub-Saharan Africa can help predict a meningitis epidemic.

The program sponsored a special issue of *Geocarto International* on "NASA Earth Science Satellite Data for Application to Public Health." This issue was published online in April and can be accessed at *http://www.tandfonline.com/toc/tgei20/29/1#.U2KVXE0U9dg*. The issue included articles on CDC/NASA collaboration; risk characterization of malaria, meningitis, and influenza; applications of aerosol optical depth observations for air quality; and heat mortality.

IX. Looking Ahead

During 2015 and beyond, the program will expand its relationship with current and future relevant NASA missions, as well as field and Earth Venture (EV) campaigns. A challenge for Earth-observing satellites measuring air quality is to distinguish between pollution high in the atmosphere and that near the surface where people live and breathe. In summer 2011, NASA began a multi-year airborne field campaign, DISCOVER-AQ, to tackle this challenge. This field campaign includes many AQAST members participating as investigators and has thus far yielded significant results that will be of great value to air quality applications. The program will continue its collaboration with DISCOVER-AQ through 2015. The area also plans to hold an AQAST results workshop in June at St. Louis University, and in December at a location yet to be named.

Sessions in 2015 are planned for the AMS Annual Meeting, American Thoracic Society, Air & Waste Management Association, the CDC/NCAR biannual colloquium on Climate and Health, and the American Society for Tropical Medicine and Hygiene.

The launch of the *Global Precipitation Measurement* Core Observatory (GPM) in 2014 inaugurated an unprecedented international satellite constellation to produce frequent global observations of rainfall and snowfall, revolutionary new data that will help answer questions about our planet's life-sustaining water cycle and improve weather forecasting, water resource management, vector-borne disease risk assessment, and habitat modeling. As part of the first *GPM* Applications Workshop in fall 2013, the Health and Air Quality program led a breakout session of community leaders and end users on transitions from *TRMM* to *GPM* and future applications of *GPM* observations. The program plans a follow-up *GPM* Applications Workshop in summer 2015 in College Park, Maryland.

The program will continue to keep abreast of studies and opportunities related to the PACE, ASCENDS, *OCO-2*, *HyspIRI*, and *GEO-CAPE* decadal survey missions. Additionally, the program is active in applications planning for the TEMPO Earth Venture mission to be launched no earlier than 2018.

The program will continue to examine "grand challenges" to the community. For example, accurate ground-level aerosol and constituent measurements from remotely sensed columnar values represent another grand community challenge. While progress

has been made in this area thanks to investments in algorithm development and targeted field campaigns (e.g., DISCOVER-AQ), large discrepancies still remain. Ozone is a critical issue in this regard; aerosols over land areas with high albedo also have large errors. Even developed countries, such as the United States, have relatively sparse ground level aerosol networks with remotely sensed observations providing critical data to fill coverage gaps. Developing countries have even fewer ground sensors, and sometimes none at all. Satellite observations for air quality will be increasingly vital in the coming years.

The Health and Air Quality Applications program has established strong relationships with federal, state, local, and international partners to identify unique applications of NASA satellite observations and realize their operational use. These applications provide critical components for integration with various forecasts, models, and decision support systems. This will continue to be the case with the launch of upcoming NASA satellite missions. NASA's participation in health and air quality applications research and related transition to operations activities currently performed with EPA, NOAA, CDC, and others fills a significant niche in national capabilities and is a vital component in current and future domestic and international programs and plans.

X. Appendix

Health & Air Quality Project Highlights from 2014

Project: Incorporating Space-borne Measurements to Improve Air Quality Decision Support Systems

PI: Arastoo Pour Biazar

Organization: University of Alabama in Huntsville (UAH)

- The uncertainties in air quality simulations due to model cloud errors have been recognized as a major problem in State Implementation Plans (SIP) of state regulatory agencies. This project developed two parallel techniques for minimizing estimates of cloud formation/removal based on satellite observations. The techniques are implemented within the Weather Research and Forecasting model which is commonly used in regulatory air quality applications. Both approaches estimate a required vertical velocity and adjust the model flow field through a variational technique to achieve the estimated vertical velocity. The first approach estimates a favorite vertical velocity based on model statistics and the second approach uses an analytical technique for such estimation. Both approaches were tested and demonstrated improvements in model cloud simulations. In September 2014, the program reported an ARL of 7, two points higher than a year ago, mostly due to a key transfer of the project to the Texas Commission on Environmental Quality (TCEQ). The first system was transferred to TCEQ and is being integrated into their operational setting. To make the transition efficient, the system was tested with a data feed and configuration similar to the operational setting at TCEQ. TCEQ

is providing complementary funding of $350,000 for the cloud work in order to address specific issues relevant to the SIP process for Texas and has signed a cooperative agreement with UAH to facilitate this relationship. The team worked with the NASA SPoRT Center to revise the data archive and delivery system. The team also addressed long-term sustainability at TCEQ and other agencies by offering workshops to train users and build capacity.

Project: Improved Estimation of Air Quality Impacts of Wildfires at Ambient Air Quality Monitors Using Grid-based Air Quality Models

PI: Robert B. Chatfield

Organization: NASA Ames Research Center

- This project provides wildfire locations, speciation and transport of emissions, assessment of the intensity of fuel consumption, and model assessment to the San Joaquin Valleywide Air Pollution Study Agency. This is to enable the agency to make an assessment of the effect of wildfires on the concentrations measured at California Air Resources Board (Cal-ARB) ground-based ambient ozone monitors. The model information forms the basis for exceptional event flagging and ozone regulation. The project provided inputs on biomass burning source strengths, compounds emitted, and plume lofting, as well as comparison of *in situ* aircraft data and ozone. The project also established a Space Act agreement with Cal-ARB to study biomass burning effects and to identify strengths and weaknesses of their simulation. The western United States and adjoining regions of northern Mexico have severe problems of particulate exposure; however, there are relatively few PM2.5 monitoring stations that allow us to understand the regional-vs-local aspects of exposure and potential for amelioration. Common difficulties of the region include relatively bright soil surfaces, which make bright aerosol difficult to retrieve, variable albedo over relatively spatial and temporal scales (watered/moist/fallow), variable terrain, the absence of a long-range regional flow, and anomalous composition. The project examines the benefits of two methodological improvements in using remote sensing area-mapped estimation of PM2.5 over bright and patterned surfaces. One direction is to improve the retrieved integral of aerosol scattering, or Angular Optical Depth (AOD). An extension of this work is an examination of mixed-layer depth estimates for shallow wintertime situations in the West. Weather-model generated depths are compared with more observationally based methods, using integrated water column and surface water vapor reports. This work makes particular use of the measurements made by the NASA multi-aircraft sampling mission known as DISCOVER-AQ - San Joaquin Valley. The second approach is to extend the work of Lee and Sorek-Hamer in making full use of direct statistical relationships between MODIS products and PM2.5 measured at the limited number of monitoring sites. Mixed-effects regression shows that two error sources may have differing patterns in space, time, and observed quantity. As progress permits, this method will be extended to border regions such as the Imperial Valley of California, the agricultural

regions in Northwest Baja California, and similar regions with relevant PM2.5 observations. The first results of these studies will be presented at the Air and Waste Management Annual Meeting in June 2015.

Project: Feasibility Study of Satellite-assisted Detection and Forecasting of Oyster Norovirus Outbreak

PI: Zhiqiang Deng

Organization: Louisiana State University

- This project has tested and demonstrated the feasibility of utilizing NASA MODIS (*Terra* and *Aqua*) data in the detection and forecasting of oyster norovirus outbreaks in coastal Louisiana. The project developed a Detection and Forecasting System for oyster norovirus outbreaks by combining environmental data from MODIS and *in situ* sensors; bacteriological data from field sampling and laboratory analysis of oysters and water; and modeling efforts.

  This project provided an innovative and practicable decision support system capable of making two types of decisions: daily/detection management decisions, and forecasting management decisions on oyster norovirus outbreaks. In fact, the modeling system developed under this initiative successfully predicted the December 2012 norovirus outbreak in coastal Louisiana. Environmental health implications of this project are best described in a testimonial by Glenn T. Cambre (public health executive director of the Louisiana Department of Health and Hospitals). He stated, “Such new insights will greatly enhance the usefulness of our program in helping detect and forecast infectious diseases within oysters and provide additional public health assurances to the citizens of Louisiana.” The project completed in April 2014. More information on this project can be found at *http://intranet.cee.lsu.edu/people/Deng/index.html*.

Project: Improve EPA’s AirNow Air Quality Index Maps with NASA Satellite Data

PI: Philip G. Dickerson

Organization: U.S. Environmental Protection Agency

- This project combined data from MODIS (AOD), OMI (nitrogen dioxide), and other sources to supplement measurements from ground-based monitors. The project team created the AirNow Satellite Data Processor (ASDP) to make operational use of satellite data products. The project increased the accuracy of P air quality forecasts due to improved information about the spatial distribution of PM2.5. The project reduced relative errors in estimating surface PM2.5 from satellite data from 50 percent to 100 percent to less than 50 percent for most of North America, and

eliminated the need for an online calculation of the AOD/ PM2.5 ratio. In 2014, the project completed a survey of the socio-economic and financial benefits of adding NASA satellite data to AirNow using face-to-face interviews in three case study locations (Denver, Colorado; Atlanta, Georgia; and Kansas City, Missouri) (*http://www.ctg.albany.edu/projects/pubs?proj=airnow&sub=pubs*). The ASDP system has been integrated into the EPA AirNow-Tech decision support system and within the production AirNow Information Management System at the AirNow Data Management Center in California. The products are being produced and sustained on the project website and EPA intends to keep the system in operation under AirNow program resources. As a result, there has been a significant improvement in the information available to air quality forecasters, public health managers, and the public. Local public health agencies now have the ability to more accurately warn the public of high PM2.5 levels.

"What I hope can come from [the satellite products] is the ability to look at more data analysis to allow us to anticipate health impacts, particularly as it relates to emergency room visits, doctor visits, [and] provider visits, related to asthma and upper respiratory illness," said Bert Malone, deputy director of the City of Kansas City, Missouri, Health Department.

The project team has implemented a NRT World Mapping System in the AirNow-Tech Navigator using LANCE MODIS products. The team also linked the NASA Global Imagery Browse Services (GIBS) in the AirNow-Tech Navigator. The GIBS are a set of standard services to deliver global, full-resolution satellite imagery in a highly responsive manner. The socioeconomic benefit analyses of the AirNow-Tech task reached new milestones when interviews with end users were conducted in Denver, Atlanta, and Kansas City, Missouri.

Project: Inverse Modeling and Attainment Analysis for Improved Decision Support of PM2.5 Air Quality Regulations

PI: Daven K. Henze

Organization: University of Colorado

- The results of the adjoint models being developed under this project will provide information regarding the impact of individual sources on multiple nonattainment monitors, inform updates to the National Emissions Inventory (NEI) for the PM2.5 precursors (NH3 and NOx), and assist the Regulatory Impact Assessment by improving the specificity of cost-per microgram metrics in terms of spatial resolution and source attributes. By constraining the U.S. ammonia emissions using NASA's Tropospheric Emission Spectrometer and the GEOS-Chem adjoint model, the project has demonstrated a reduction in the uncertainties in the U.S. ammonia emissions and recently documented the results in a refereed journal. Additionally, the project quantified impacts on human health of aviation emissions using the

GEOS-Chem model. Significant accomplishments in model development over the last year included the use of remote sensing observations to constrain emissions of short-lived species, and adjoint models for aerosol-gas partitioning. In 2014, the nested version of the GEOS-Chem adjoint has been applied over the United States to estimate the PM2.5 health-related damages per ton of emission for each species, sector, and grid-cell. The species-specific health impacts are being assessed at the county level for the year 2008. CMAQ adjoint simulations for black carbon are in progress. These will allow us to further assess the impacts of model resolution and model error on these estimates. The TES NH3 inversion system is now being used by researchers at EPA AMD to constraint ammonia sources using remote sensing observations.

Project: Evaluate, Enhance, and Apply Aura Products in Public Health Tracking

PI: Yang Liu

Organization: Emory University

- This interdisciplinary team, awarded through the NASA ROSES 2013 *Aura* solicitation, brings together experienced remote sensing experts, environmental exposure modelers, and epidemiologists. By integrating ground observations and atmospheric chemical transport model simulations, the team plans to enhance the existing OMI surface UV (OMUVB) product by better accounting for the impact of absorbing aerosols in the retrieval of surface UVB irradiance and erythemal doses. In addition, OMUVB uncertainties due to SO2 and NO2 absorption will be analyzed and corrected primarily in polluted urban regions. The conversion from the dose rate estimated at OMI overpass time to that at the local noon time and eventually to the daily-average dose will also account for diurnal change of aerosols. After evaluating the accuracy of the enhanced OMUVB product with ground measurements, the project will spatially match OMUVB exposure doses to 3,100 U.S. counties to study the association with county-level melanoma incidences reported by NCI. Major confounding factors such as indoor tanning use, education, poverty, health insurance, and rural-urban status will also be processed and included in the epidemiological model. The project team will work closely with the CDC Tracking Branch to develop UV exposure indicators and measures as well as detailed documentation for public release on the Tracking Network.

Project: Integration of Airborne Aerosol Prediction Systems and Vegetation Phenology to Track Pollen for Asthma Alerts in Public Health Decision Support Systems

PI: Jeffrey C. Luvall

Organization: NASA Marshall Space Flight Center

- The project developed a deterministic model for predicting and simulating pollen release and downwind concentration to study dependencies of phenology on meteorology. This model, known as the Pollen REgional Atmospheric Model (PREAM), is expected to be a real-time, rapid response pollen release and transport system as a component of the New Mexico Environmental Public Health Tracking System (EPHTS).

  The project has provided a better understanding of Juniper pollen dispersion and impacts of environmental factors on pollen counts. The project has also worked with end users to modify decision support systems such as SYRIS to accept pollen tracking data. As this project was reaching completion in October 2014, data products were tested and provided to the New Mexico Department of Health for integration into the EPHTS.

Project: Linking NASA Satellite Data and Science to Enhance Fire Emissions within the EPA's National Emissions Inventory: Developing Agricultural/Rangeland Fire Emissions Estimates, Connecting Models to Plume Injection Height Data, and Verifying Modeled Emissions Estimates

PI: Amber J. Soja

Organization: National Institute of Aerospace

- This project focuses on the application of NASA satellite, aircraft and *in situ* observations to develop products designed to enhance the existing National Emissions Inventory (NEI) and Community Multiscale Air Quality (CMAQ) model. This will be done by improving estimates of area burned and fire emissions in poorly represented agricultural and rangelands and using CALIPSO's vertically resolved measurements to build an observationally based plume height data base. The project delivered both state- and county-level cropland burned area emissions estimates for the contiguous United States to the Air Quality Analysis Group, Office of Air Quality Planning and Standards of EPA. Several states opted to use the emissions estimates generated during this project in their NEI reporting. The project also completed the development, mapping, and integration of the 2009 and 2010 cropland fuels into the main fuels map used in the Wildland Fire Emissions Information System, a Web-based tool. The project also validated initial CALIOP plume height results with coincident MISR data as an initial step towards building a plume height data base.

Project: Linking NASA Environmental Data with a National Public Health Cohort Study to Enhance Public Health Decision Making

PI: Leslie McClure

Organization: University of Alabama in Birmingham

- This project evaluated the linkages between selected public health outcomes and environmental risk factors using data inputs including REGARDS data on cognitive function collected annually since 2003, as well as data on hypertension, cholesterol, and inflammatory markers. Remotely sensed data from MODIS LST and AOD products were utilized in conjunction with EPA ground observations and solar irradiation data from the NARR to develop environmental data products for linkage to and analysis of the public health data. Following data linkage and statistical evaluation, data products and research results were provided to the CDC WONDER, from which they will be available to federal agencies, state health departments, and other organizations.

  At the completion of this project in September 2014, Sigrid A. Economou, Centers for Disease Control and Prevention, stated, “These data provide a useful addition to CDC WONDER, allowing public health researchers and policy makers to better include environmental exposure data in the context of other health data available in the CDC WONDER system.”

Project: Monitoring and Forecasting Cyanobacterial Blooms for Public Health Protection and Response

PI: Richard Stumpf

Organization: NOAA

- Cyanobacterial harmful algal blooms (CyanoHABs) are of particular concern in drinking water and recreational water supplies due to their potential to produce toxins. This includes areas in western Lake Erie, Saginaw Bay, and many other Midwest lakes and estuaries that are used for recreation and drinking water. The goal of this project was to improve the ability to detect and monitor CyanoHABs and to improve nowcasting and forecasting capabilities in western Lake Erie through assimilation of information into the NOAA HAB Bulletin. In addition, the satellite-derived products being developed for western Lake Erie are being analyzed for use in other regions (e.g., Chesapeake Bay, Florida, and inland lakes in Ohio). This project established methods to identify environmental thresholds that indicate the potential for cyanobacterial blooms to form or persist, and these data sets are being made available to CDC and local departments of health.

  This forecast system has been successfully deployed and is being evaluated by end users (e.g., Ohio Environmental Protection Agency, Ohio Department of Natural Resources, Toledo Water Supply, Sandusky Water Supply, Cuyahoga Department of Health, and Florida Department of Health). Improved NOAA HAB Bulletin products from this project alerted the city of Toledo to the threat of a major HAB to its water supply in August 2014. The Maryland Department of Natural Resources is

preparing to produce a Chesapeake bulletin from the products at their own expense. This project was completed successfully in September 2014.

A partner of the project, Linda Merchant-Masonbrink of the Ohio Environmental Protection Agency, Division of Surface Waters, stated that these products "minimize resources necessary for large scale surveillance. [They] help us focus our resources."

Project: Reducing Uncertainties in National Smoke Emissions Modeling as Applied in the BlueSky Framework: Dead and Live Fuel Moisture, Plume Rise, and Heat Release

PI: Dana Coe Sullivan

Organization: Sonoma Technologies, Inc.

- The primary objective of this project is to incorporate NASA Earth science results into a decision support tool for wildfire-related health and air quality management to reduce specific uncertainties associated with modeling air pollutant emissions and transport from biomass burning. The key uncertainties being addressed are biomass consumption estimates derived from sparse fuel moisture data and plume heights using NASA *TRMM*, MODIS, and MISR. The project completed program modules for live and dead fuel moisture, fire radiative power, and plume heights.

  In 2014, all new modules funded under this NASA grant have reached ARL 9, having been integrated with the pre-existing BlueSky Framework for general distribution and use. The augmented system provides additional insights into climate and air quality that air quality managers and foresters can use to better protect public health and manage natural resources. "The level of detail from projects like this really helps us," said Trent Procter, air quality program manager, U.S. Forest Service, Region 5. "Our success in wildfire monitoring and management is largely because of the scale of modeling now available in BlueSky."

  A benefits study was completed in 2014 to investigate prescribed burn outcomes for the 2012-2013 season.

Project: Evaluate and Enhance *Suomi-NPP* Products for Air Quality and Public Health Applications

PI: Jun Wang

Organization: University of Nebraska – Lincoln

- This new project, awarded through the NASA ROSES 2013 S-NPP solicitation, is designed to evaluate and enrich the utility of *Suomi National Polar-orbiting*

Partnership (S-NPP) data for applied science research. This project will evaluate improvements in the application of the VIIRS aerosol product for operational monitoring of PM 2.5 air quality in the Remote Sensing Information Gateway (RSIG) at the EPA. This information will also be provided to the CDC Environmental Public Health Tracking Network.

Project: Using NASA Satellite Aerosol Optical Depth Data to Create Representative PM2.5 Fields for Use in Human Health and Epidemiology Studies in Support of State and National Environmental Public Health Tracking Programs

PI: Stephanie Weber

Organization: Battelle Memorial Institute

- This feasibility project focused on PM2.5, a critical air pollutant. The U.S. nationwide PM2.5 pollutant monitor network has spatial and temporal gaps, particularly in suburban and rural areas. For this project, PM2.5 concentration information from ground-based monitors was combined with NASA satellite aerosol optical depth (AOD) and the CMAQ air quality model using a statistical hierarchical Bayesian model (HBM). This was done to generate a single, and hopefully more representative, data set for use in health studies by national, state, and local offices. Co-investigators at the New York State Department of Health and Maryland Department of Health analyzed the correlation between combined PM2.5 data sets and health outcome data sets in New York City and Baltimore, respectively.

  As a result of delays in IRB approval to use emergency room and inpatient data in Maryland, the evaluation of whether the addition of AOD to the PM2.5 estimated surfaces leads to a better prediction of adverse health effects is still being evaluated by NYSDOH and MDH. The project team completed a manuscript for publication as this project ended in June 2014.

Project: NASA and NAAPS Products for Air Quality Decision Making

PI: Douglas L. Westphal

Organization: Naval Research Laboratory

- The NASA-NAAPS project produces and distributes Naval Research Laboratory NAAPS real-time and historical analyses and forecasts of long-range aerosol transport to air quality decision makers via Washington University's DataFed. In 2013, the project made a concerted effort to extend the exceptional event (EE) DSS software to support assessment of potential EE candidate events. In 2014, user documentation contained in Web/wiki pages, training videos and application use cases were published and widely disseminated. The EE DSS was introduced to the

States and the EPA regions through a series of webinars, attended by over 100 State and EPA analysts, and NASA seminars, including one for the Texas Commission on Environmental Quality on February 25-27, 2014.

The EE DSS was applied for screening Exceptional Event candidate samples for three pollutants: PM2.5, PM10, and Ozone for the entire United States, during 2010-2012. Over 10,000 EE candidate samples were identified by the EE DSS and made available to the States and EPA for inclusion in the flagging process. Following the application of the DSS to several events, Neil Frank (technical lead of the EPA Federal Exceptional Events Rule team) said the improved EE DSS "makes detection and documentation of exceptional events much easier. This helps both the states and the EPA with implementing the EER."

AQAST Project Highlights from 2013

Project: Improving Air Quality Analysis through a Closer Integration of Observations and Models

PI: Gregory R. Carmichael

Organization: University of Iowa

- Utilizing data from TES, OMI, SEAC4RS, and other sources, this project seeks to improve the capability of modeling fine particle concentrations during wintertime in the Midwest, Northeast, Mountain West, and California's Central Valley to establish an operational urban/regional air pollution forecasting system. The goal is to provide decision support to local, state, and regional air quality managers.

- In 2014 the project applied a state-of-the-art data assimilation system to estimate the effect of adding geostationary satellite data to aerosol simulations. Adding geostationary satellite data improved the simulations of surface PM significantly over using LEO data. This work shows that these new data streams have the potential to really improve prediction skill, but more work is needed to improve the modeling and retrievals in order to be better prepared to utilize the data that will come from the new geostationary satellites as they come online.

Project: Inputs Influencing Ozone and Particulate Matter Concentrations and Sensitivities

PI: Daniel Cohan

Organization: Rice University

- This project is simulating ozone and particulate matter and their sensitivities to emissions perturbations, and exploring how these change with satellite-based inputs and alternate inputs for natural conditions. The project has implemented an advanced soil NO emissions scheme and are comparing its predictions of NO_2 with ground-based monitors and OMI satellite-based column retrievals. We are also exploring how *GOES* satellite observations of clouds influence biogenic emissions and photolysis rates, thereby influencing pollutant concentrations and sensitivities.

  In 2014, the project refined its implementation of the soil NO scheme in the CMAQ model and tested its impacts for a full-year simulation. The project obtained a new full year continental U.S. CMAQ simulation from EPA which will be used for further testing. In 2015 the project will test how results from this simulation depend upon soil NO emissions, satellite-observed radiation conditions, and improved estimates of wildfire emissions. The project will also be testing alternate methods for assessing the responses of ozone to large scale changes in emissions and predicting the amounts of emission reductions needed to attain tighter ambient air quality standards.

Project: Demonstrate Utility of Aura/OMI Nitrogen Dioxide (NO_2) Data for AQ Applications

PI: Bryan Duncan

Organization: NASA

- This project assesses the utility of *Aura*/OMI nitrogen dioxide (NO_2) tropospheric column data for various air quality applications, including showing the good correspondence of trends and variations estimated from the data with EPA AQS surface NO_2 data and NO_x emissions data reported to CEMS.

  The project team developed a review article “Satellite Data for U.S. Air Quality Applications: Examples of Applications, Summary of Data End-User Resources, Answers to FAQs, and Common Mistakes to Avoid” published in *Atmospheric Environment*. The PI led a NASA “Air Quality” media campaign that used OMI NO_2 data to convey the message that U.S. air quality has improved by 30 percent to 40 percent in the last decade, but further reductions are necessary for all Americans to have healthy air. Several AQAST members, including the PI, were interviewed by more than 30 news organizations, including CNN, Fox News, and the Weather Channel.

Project: Understanding Colorado Front Range Summertime Ozone, Long-range Pollution Transport and Stratospheric Intrusion Events

PI: David Edwards

Organization: National Center for Atmospheric Research

- Modeling Colorado Front Range air quality proves a significant challenge due to the difficulty for models to simulating the complex meteorology and transport of this region and because of large uncertainties in existing emission inventories. NCAR/ACD has taken a large step towards better understanding the drivers behind high summertime ozone by spearheading a major field campaign in the summer of 2014, the Front Range Air Pollution and Photochemistry Éxperiment (FRAPPÉ). The project, funded by the State of Colorado and NSF, took place together with the NASA DISCOVER-AQ mission and yielded the most comprehensive and detailed observational data set for addressing this question.

  The campaigns were a great success and NCAR, NASA, NOAA, and university and other groups involved in the FRAPPÉ and DISCOVER-AQ missions have started analyzing the data in close collaboration with the Colorado Department of Health and Environment. First results will be presented at the FRAPPÉ and DISCOVER-AQ Science Team Meeting from May 4-8, 2015 at NCAR.

  A main research focus of the NCAR AQAST activity led by FRAPPÉ Co-PI Gabriele Pfister is to conduct WRF-Chem simulations and utilize the data set to evaluate and improve the model performance. The results will provide a much better understanding of the factors driving Front Range ozone air quality and allow for developing robust emission control strategies to reduce ozone air pollution.

- The FRAPPÉ field catalog (*http://catalog.eol.ucar.edu/FRAPPE)* includes forecasting and measurement reports generated during the campaign.
- The data archive for FRAPPÉ and DISCOVER-AQ data is housed at NASA Langley and will be made publicly available in February 2015 (*http://www-air.larc.nasa.gov/missions/discover-aq/discover-aq.html).*
- The campaigns have been accompanied by a strong education and outreach component which included a public Open House at the airport, involvement of teachers and students, development of educational material, outreach to media, and more (*https://www.eol.ucar.edu/field_projects/frappe*).

Project: Processes Influencing the Daily-to-Decadal Variability of U.S. Background Ozone Levels

PI: Arlene Fiore

Organization: Columbia University/Lamont-Doherty Earth Observatory

- This work combines models, space-based, sonde, and ground-based measurements to identify events influenced by high background and to analyze the relative roles of background versus regional air pollution under 21st century global change scenarios. This project addresses a need voiced by U.S. air agencies for source attributions during high-O_3 events to inform attainment determinations and state implementation plans. It also provides guidance for decadal-scale planning as to the impacts from changing regional and global emissions in the context of both a warming climate and decadal climate variability. Expected end users include air quality management agencies at the federal and state levels.

  In 2014, the project team published a paper showing discrepancies in NAB ozone estimates from two independent global models (GEOS-Chem and GFDL AM3), attributed to differences in the representation of stratospheric intrusions, wildfires, lightning, and isoprene oxidation chemistry. The team also published a paper showing that projected decreases in regional NOx emissions lead to a reversal in the seasonal cycle over the northeastern U.S., with a late-winter, early-spring peak, as observed currently at remote sites. Rising methane can increase the amplitude of this peak, and offset the summertime NOx-driven decreases. A warming climate increases monthly mean surface ozone in summer by a few ppb in the NE U.S., but these changes can be offset with NOx emission controls. The team is also applying multi-year GEOS-Chem and AM3 simulations for 2005-2012 to investigate specific pollution episodes of interest to air agencies and for examining seasonal and inter-annual variability in background contributions to NO_2 columns.

Project: Using OMI Data to Estimate Point Source Emissions and Atmospheric Lifetimes of NO_x and SO_2 / Ozone Garden Project and Coordination of Outreach Activities for AQAST

PI: Jack Fishman; Co-I Benjamin de Foy

Organization: St. Louis University

- This project uses satellite measurements to create high-resolution maps of NO_x and SO_2 around point sources. By better estimating chemical lifetimes and emission inventories, local air quality issues can be better understood. The intended end users include, among others, developers of emissions inventories at regional agencies.

  The project team did a thorough evaluation of methods for retrieving emission rates and lifetimes using OMI data and Continuous Emission Monitoring System (CEMS) data, which is currently under review. The methods were found to be accurate

provided that sufficiently long time periods are used for data averaging and that a correct dispersion lifetime is used. The project team is now looking at emission estimates over megacities and comparing them with existing inventories. As part of the NO_x Tiger Team, the team will further refine the analysis of emissions over the U.S. in combination with Air Quality Model Reanalysis runs.

Work is continuing to analyze ozone sonde data from the SEACIONS campaign with a combination of *in situ* measurements, satellite data, and numerical simulations.

In 2014, the project expanded the Ozone Gardens Project to an additional six sites nationally in addition to the three that are operated in the St. Louis metropolitan area. Documentation of this education/public outreach activity was published in the *Bulletin of the American Meteorological Society* and was featured on the cover of the August 2014 issue (Fishman et al., 2014, The St. Louis Ozone Gardens: Visualizing the Impact of a Changing Atmosphere, 95, 1171-1176).

Project: Using Remote Sensing and Adjoint Modeling for Integration of Climate Impacts into Design of Ozone and Aerosol Control Strategies

PI: Daven Henze

Organization: University of Colorado at Boulder

- This project uses combinations of remote sensing data and regional-to-global adjoint sensitivity analysis with the GEOS-Chem chemical transport model to quantify the contribution of emissions to ozone and particulate health, ecosystem, and climate impacts. End users include the U.S. Department of State, EPA, USFS, and United Nations.

  In 2014, the team continued to explore the sources of O3 contributing to vegetative exposure to O3. Following up on the multi-model comparison from the previous year (Lapina et al., JGR, 2014), GEOS-Chem adjoint modeling was applied to estimate long-range contributions from foreign nations following future emission scenarios out to 2050; in several scenarios long-range contributions are estimated to exceed domestic influences within several decades. The team also established the first O3 gardens in the western United States, one at Colorado State University-Boulder campus and one at NCAR. In addition, the team continued to work on emissions response coefficients for climate, ecosystem, and human health impacts of aerosol, aerosol precursor, ozone precursor, and methane emissions to deliver to the U.N. Climate and Clean Air Coalition. Lastly, as part of the Reactive Nitrogen Deposition Tiger Team, GEOS-Chem and CMAQ sensitivity modeling studies have been performed to estimate the contribution of different sources of NH3 and NOx deposition of reactive nitrogen above critical loads in U.S. Class I areas.

Project: Atmospheric Processes Affecting Emission Sector Contributions to O_3 and $PM_{2.5}$ Episodes

PI: Tracey Holloway

Organization: University of Wisconsin at Madison

- The project uses satellite data, ground-based measurements, and the EPA CMAQ model to evaluate U.S. air quality at the regional to national scale and characterize the impacts of transportation, electricity, and biogenic emissions on air quality.

  2014 saw the publication of three research publications, one that evaluates transportation alternatives for air quality (Bickford et al., 2014 *ES&T*), one that evaluates electricity alternatives for air quality (Plachinski et al., 2014 *Atmos. Env*.), and one that evaluates climate impacts on air quality and health (Patz et al., 2014, *JAMA*). In addition, the broader work of the AQAST team was highlighted in a special issue of *EM*, the magazine of the Air and Waste Management Association, with Holloway leading the "success story" for satellite data applied to air quality management in Colorado (Witman et al., 2014 *EM*).

  Major accomplishments from 2014 include the evaluation of ozone production regimes in China (Jin and Holloway, in preparation), quantifying the sensitivity of ambient NO2 to weather variables (Harkey et al., in preparation), and an evaluation of power plant NOx and SO2 emissions as a function of ambient temperature (Kladar et al., in preparation; Meier et al., in preparation). Our satellite re-gridding software, the Wisconsin Horizontal Interpolation Program for Satellites, (WHIPS) has been upgraded with new capabilities and errors corrected. WHIPS now allows users to re-grid Level-2 data products on a custom grid, better supporting air quality model evaluation.

  Beyond research, Dr. Holloway has co-led a Tiger Team on air pollution episodes across the eastern United States (with Dr. Fiore). This effort has produced an engaged community of AQAST members and air quality managers from 15 different states and agencies meeting monthly. Holloway also maintains the @NASA_AQAST Twitter account (near 1600 followers as of 2/3/15) and the *www.aqast-media.org* website, promoting and tracking press coverage of AQAST activities.

Project: Aerosol Data Products for Assimilation into Air Quality Models

PI: Edward J. Hyer

Organization: Naval Research Laboratory

- This project integrates weather data with satellite observations of fires to enhance short-term prediction of fire activity to support applications needing forecasts of air quality.

  The meteorology of extreme fire behavior and pyroconvection was analyzed using the August 2013 Rim Fire in California, the third largest wildfire in California history, to examine the drivers of fire behavior at different layers of the atmosphere and different forecast lead times. This analysis is now published in the *Bulletin of the American Meteorological Society* (Peterson et al., 2015 *http://journals.ametsoc.org/doi/abs/10.1175/BAMS-D-14-00060.1*). This work involved researchers at Stanislaus National Forest, and will lead directly to improved prediction of both extreme fire spread and pyroconvection. With Mr. Arunas Kuciauskas, the NRL team prepared an analysis on behalf of Luis Rosa at the National Weather Service in Puerto Rico describing the onset, magnitude, and duration of a large dust event associated with a Saharan Air Layer. This analysis was presented at the American Meteorological Society meeting in January 2015 (*https://ams.confex.com/ams/95Annual/webprogram/Paper267286.html)*, and ongoing work is looking at delivering products to NWS Puerto Rico to assist in early warning and forecasting of Saharan Air Layer events. In addition, the group published a study in collaboration with the University of Nebraska describing the implications of the NPP VIIRS sampling strategy on fire detection and fire characterization (Polivka et al. IEEE Geoscience and Remote Sensing Letters, in press 2015).

Project: AQAST Membership and Leadership

PI: Daniel Jacob

Organization: Harvard University

- The project addresses emerging air quality management issues by using a range of Earth Science data and tools. A major focus is the application of the GEOS-Chem global model with nested resolution over North America. Other applications involve the GISS global climate model for study of chemistry-climate interactions. Interpretation of satellite and aircraft data for U.S. air quality is a top priority.

  A major accomplishment for 2014 was the demonstration that formaldehyde (HCHO) data from the OMI satellite instrument can be used to quantify large anthropogenic VOC sources such as from Houston and other urban/industrial centers. This involved oversampling of the OMI HCHO data to achieve sub-pixel resolution. The work was published in *Environmental Research Letters* (Zhu et al., 2014). Since then, the project team has collaborated with air quality managers at EPA/NCEA to produce a U.S. map of surface HCHO concentrations from the OMI satellite that can be used to assess the national public health risk from exposure to elevated HCHO, which is the top Hazardous Air Pollutant of concern to EPA. The project is also using

the satellite data to detect trends in anthropogenic VOC emissions over the past decade, involving in particular the rise in oil and gas production.

The project focused on (1) the influence of synoptic scale meteorology on 1980-2012 ozone pollution over the eastern United States; and (2) prediction of the frequency of ozone episodes in the 2050s atmosphere over the entire United States. The Center for Disease Controls has expressed interest in the prediction of ozone episodes, and the project team is working with George Luber, Associate Director for Climate Change in the Division of Environmental Hazards and Health Effects, to provide the CDC with data and prediction tools.

Project: AQAST Membership

PI: Pius Lee

Organization: NOAA

- This work assimilates quality assured observations into current state-of-science chemical transport models to address an increasingly pressing need of knowing the best retrospective estimates of the long-term chemical composition and evolving trends of the troposphere.

  In the past year, the project team constructed a prototype atmospheric chemical re-analysis system using archived meteorology from NOAA Centers for Environmental Prediction to drive CMAQ and apply the Optimal Interpolation assimilation algorithm to integrate MODIS AOD and surface AirNow PM2.5 measurements to derive re-analysis chemical fields.

Project: Improving Satellite Aerosol Remote Sensing Data for Air Pollution Health Research in the Southeastern United States

PI: Yang Liu

Organization: Emory University

- This year the project focused on using satellite and ground-based measurements of wild and prescribed fires to enhance the estimation of PM2.5 concentrations in the Southeastern U.S., and exploring the application of satellite-based PM2.5 exposure estimates in acute health effects research in Colorado.

The project team examined whether remotely sensed fire count data could improve PM2.5 prediction accuracy in the southeastern United States. MODIS fire count data were shown to have improved model prediction accuracy particularly in southern Georgia and in the spring season due to higher fire occurrence. The team's findings indicate that fire count data provide measurable improvement in PM2.5 concentration estimation, especially in areas and seasons prone to fire events. The project also investigated associations between satellite-estimated daily PM2.5 concentrations and emergency department visits for six pediatric conditions in urban, suburban, and nonmetropolitan areas of Georgia. The team found that pediatric ED visits for asthma or wheeze and for upper respiratory infection were significantly associated with PM2.5 concentrations in Georgia.

Project: Air Quality Applied Science Team (AQAST) Membership – Physical Atmosphere

PI: Richard McNider, University of Alabama in Huntsville

Organization: University of Alabama in Huntsville

This project focuses on the improvement in the representation of the physical atmosphere in SIP models and air quality forecasting models.

Highlights of 2014 included:

- Processed Photosynthetic Active Radiation (PAR) from the UAH *GOES* insolation archive for several state agencies, including Wisconsin and Texas. The system uses a method developed by Pinker and Lazlo to calculate a conversion factor based on cloud albedo and solar zenith angle to convert insolation to PAR. Applied Sciences received a letter from LADCO acknowledging AQAST.
- Collaborated with Texas Commission on Environmental Quality on improving biogenic emissions using satellite PAR.
- Provided satellite cloud transmittance and cloud top information for use in photolysis calculation for the Reanalysis Tiger Team
- Began an inter-comparison of satellite surface skin temperature products for use in model evaluation and for assimilation to improve model boundary layer performance. Products compared NOAA CLASS *GOES* Skin Temperature, MSFC Physical Retrieval Skin Temperature and MODIS skin temperatures. Found anomalous warm temperatures in NOAA CLASS product in the High Plains. Found some stripping issues in MSFC product.
- Followed up recommendation from Atlanta Physical Atmosphere Workshop to use fine resolution satellite skin temperature rather than 2-meter air temperature as assimilation data in the Pleim-Xiu surface scheme. Diagnosed skin temperature consistent with Pleim-Xiu fluxes and tested against FIFE data.

- Collaborated with TCEQ on using satellite skin temperatures to improve specification of variables in land surface schemes.
- Served on Program Committee at the Meteorology and Air Quality Conference at the University Of California-Davis in September 2015.

Project: Contribute to Oil and Natural Gas (ONG) Tiger Team

PI: R. Bradley Pierce

Organization: NOAA NESDIS

- This project focuses on development of high spatial resolution OMI NO2 retrievals by using VIIRS day night band (DNB) composite radiances to spatially refine OMI NO2 retrievals, evaluation of Western Region Air Partnership (WRAP) and U.S. EPA NEI 2011 emission inventories using OMI NO2 columns, and conducting air quality model sensitivity studies to characterize the impact of ONG emissions on western U.S. air quality.

  Results this year show that using VIIRS DNB aggregated radiances to enhance OMI NO2 spatial resolution shows promise and provides a means of generating high resolution NO2 retrievals on a swath-by-swath basis that is suitable for regional AQ model evaluation and data assimilation applications. Comparisons between OMI Berkley High Resolution (BEHR) NO2 columns and 2008 WRAP NO2 emission inventories shows reasonable (0.3-0.6) correlations with aggregated 2008 WRAP NO2 emissions for urban areas (Salt Lake City, Phoenix, Denver, Denver-Julesburg Basin) and some western U.S. O&G regions (Uinta and Piceance Basins). CMAQ oil and gas sensitivity studies during July 2007 using Lake Michigan Air Directors Consortium (LADCO) base emissions plus WRAP oil and gas emissions show mean surface ozone sensitivities up to 0.3 ppbv over eastern Utah, associated primarily with up to 10ppbv increases in NOx emissions within the San Juan Basin.

  In 2015 the project intends to validate then spatially enhanced OMI NO2 retrievals using *in situ* and remote (GeoTASO) NO2 measurements during 2013 DISCOVER-AQ and 2014 FRAPPE/DISCOVER-AQ missions. The project will use enhanced OMI NO2 retrieval to evaluate NOAA NAM-CMAQ and RR-Chem AQ model results during 2011 and 2014 DISCOVER-AQ missions and evaluate the sensitivity of surface ozone to 2011 NEI oil and gas emissions using July 2011 WRF-CHEM oil and gas sensitivity experiments.

Project: Improving Operational Regional Air Quality Forecasting Performance through Emissions Correction Using NASA Satellite Data and Surface Measurements

PI: Armistead Russell

Organization: Georgia Institute of Technology

- This project uses emission correction methods that incorporate OMI and MODIS retrievals and surface measurements to improve the operational regional air quality forecasting performance. The project is intended to provide more accurate and targeted information for dynamic air quality management. The team built a beta version of HiRes2, a model-based air quality forecasting system, which directly integrates observations to continually update emissions inventories for better performance of air quality forecasting. The system also forecasts source impacts on air quality for power plants and vehicular emissions.

  A public website was created to disseminate forecasting products on a daily basis (*https://forecast.ce.gatech.edu*). Satellite estimates of fire emissions were compared to estimates based on ground-based information such as the types and amounts of forest fuels consumed, and the progression of the fire over the burn area. Smoke concentrations simulated by a dispersion model were compared to aircraft measurements to determine the level of uncertainty in satellite emission estimates. Prescribed burning is one source that is more prone to dynamic air quality management than others as burns can be deferred to another day. An experimental, weather- and ecological need-based prescribed burn forecasting capability has been developed for prescribed burn impact forecasting.

  In 2015 the team will continue to evaluate HiRes2 forecast performance and develop new functions such as integration of satellite-based fire emissions estimates and burn permit information into the forecast. Source-impact forecasting for the prescribed burning operation in Georgia will be started. Dynamic management opportunities will be explored for prescribed burns in view of ecological and air quality goals.

  A third area of interest to the team is repurposing the forecast fields for use in health analyses. The forecast fields are being fused with both ground and satellite-based observations to develop exposure fields. Originally funded by EPA, it is expected that the improved performance in the project's forecasting will lead to similar improvements in exposure fields.

Project: Assessment of the Applicability of Current Worldwide Studies of Satellite Retrievals and Emissions Estimation to U.S. Air Quality Management

PI: David Streets

Organization: Argonne National Laboratory

- The project assesses the current capability of using satellite retrievals, particularly of NO_2 and SO_2, to estimate the emissions from point and area sources with reasonable accuracy, and to determine the conditions under which this capability is most reliable. The project is intended to help U.S. air quality managers make use of satellite retrievals to verify, correct, and supplement spatial and temporal estimates of current emissions and trends in North American inventories (e.g., United States, Canada, and Mexico).

  Over the past year, the project team completed the work on using OMI NO_2 retrievals to estimate NO_x emissions from major U.S. urban areas for the full period of 2005-2014. The team highlighted the effects of wind fields on the satellite observations and separately used the OMI data under weak wind and strong wind conditions to determine the NO_2 burdens and NO_x emissions, respectively, for 35 selected cities. The refined analysis by the team shows that the total NO_x emissions and NO_2 burdens over U.S. cities have decreased by 43 percent to 49 percent during the past decade.

  The team also processed the latest OMI NO_2 retrievals developed by Lok Lamsal of NASA/GSFC for the period of 2005-2013. These data will be used in the Tiger Team project led by this team to verify and improve the current bottom-up U.S. NO_x emissions and quantify source-specific contributions. A review article about the current capability of space-borne instruments in detecting and quantifying power plant emissions was published in an AQAST special issue of the AWMA's *EM* journal in February 2014. In collaboration with AQAST member Benjamin de Foy, the team participated in a model evaluation of alternative methods of estimating NO_x emissions and chemical lifetimes from the satellite retrievals.

Project: Improved Web-based Access to NASA and NOAA Airborne Data Sets in Support of Chemical Transport Model (Regional and Global) Evaluation

PI: Jim Szykman

Organization: EPA

- This Tiger Team (TT) project is designed to extend the development of an interoperable Web-based infrastructure to highlight added value of NASA data for use in model evaluation, constraints on emission fields, and provide visualization capabilities to present data in a user-ready and policy relevant manner.

  The project team efforts continued to focus on increasing the overall ARL of the underlying Web-enabled infrastructure. Partner agency (EPA) resources were used to develop a new EPA RSIG 3D application that would provide a user agency

support tool to support the overall objectives of the project. The 3D Application was functionally demonstrated at the NASA ARSET Training held at EPA NC Campus in September 2014. The underlying application demonstrated the operational capability to render CALIOP and NASA airborne data in 3D, effectively moving the ARL from 4 to 7. Under this TT effort the RSIG-to-TAD (NASA Tool for Airborne Data) connection was validated in RSIG environment (ARL 5). Additionally, the team efforts focused on creating the UAH-RSIG Web service (OGC-WCS) to increase user access to *GOES* satellite products for use in WRF/CMAQ/CAMx and for the ability to access and visualize TF-HTAP & CCAC global model runs, and have demonstrated this capability at an ARL of 4.

Project: Optimizing Air Quality Forecasts with NASA Observations and Economic Data

PI: Anne M. Thompson

Organization: Pennsylvania State University

- Core Project Goal: Evaluate existing satellite products for Air Quality (AQ) applications with emphasis on use of data collected during NASA field campaigns. Develop and evaluate innovative approaches to new satellite products for AQ managers.

  Oil & Natural Gas (ONG) Tiger Team Goal: Evaluate satellite products for Air Quality (AQ) applications specific to understanding trace gas burdens near and downwind of four main regions with active US Oil & Natural Gas (ONG) extraction sites: Appalachian Basin (PA, MD, OH, WV), Williston Basin (ND), Barnett (TX), and UT-CO-WY Basins. AQM customers: CENSARA, WRAP, Colorado Dept. of Public Health & Environment; Maryland Dept. of the Environment.

  Core Project Accomplishments: Two studies carried out: (1) Stratospheric intrusions identified with NASA campaign data from DISCOVER-AQ (Maryland & Houston) and SEAC4RS were accurately simulated with new GEOS-5 tracer model. Verification was conducted with OMI total ozone (tropospheric ozone comparison pending). Results presented at AQAST 7, AQAST 8, DISCOVER-AQ (2/14), SEAC4RS STM (4/14), and Fall AGU-2014; (2) Applied Self-Organizing Maps (SOM), a clustering approach, to classify > 4000 tropospheric ozone profiles from 4 US stations with long-term ozone soundings (Boulder, Trinidad Head, Wallops, and Huntsville). The optimum number of statistically distinct mean profiles (below 12 km) is 16; one station only shows the influence of imported pollution (Trinidad Head) and only one has a distinctly higher tropopause (Huntsville). SOM results will be used to evaluate existing tropospheric ozone satellite products.

  ONG Accomplishments. (1) TES global observations from 2005 through 2011 were analyzed to compute anomalies (from regional background methane) over the 4

shale gas basins (as above, centered in PA, CO, TX, and ND). Between the period 2006-2008 and 2009-2011, positive anomalies, showing the impact of rapid increases in number of drilling operations, increased ~5-10% over all 4 basins. Reported at AQAST7, AQAST8, CENSARA Meeting in St Louis, 4/14; Fall AGU-14; (2) During DISCOVER-AQ Colorado deployment, July-August 2014, specialized graphs for AQM based on aircraft, surface (NATIVE) and satellite data of methane and related VOCs were posted through websites (*http://gator.psu.edu*) and social media through UMD/ESSIC (e.g., Twitter - @MDGatorTeam and blog - *http://mdgatorteam.blogspot.com*).

Abbreviations

AIRS: Atmospheric Infrared Sounder
AJAX: Alpha Jet Atmospheric eXperiment
AMS: American Meteorological Society
AMSR-E: Advanced Microwave Scanning Radiometer-EOS
AOD: aerosol optical depth
AQAST: Air Quality Applied Sciences Team
ARL: Application Readiness Level
ASDP: AirNow Satellite Data Processor
AVHRR: Advanced Very High Resolution Radiometer
Cal-ARB: California Air Resources Board
CALIOP: Cloud Aerosol LIdar Orthogonal Polarization
CALIPSO: Cloud-Aerosol Lidar and Infrared Pathfinder Satellite Observation
CalNEX: California Nexus
CAMx: Community Atmosphere Model
CDC: Centers for Disease Control and Prevention
CEQ: Council on Environmental Quality
CMAQ: Community Multiscale Air Quality
CNES: Centre national d'études spatiales
CoP: community of practice
CyanoHAB: Cyanobacterial harmful algal bloom
DISCOVER-AQ: Deriving Information on Surface conditions from Column and Vertically Resolved Observations Relevant to Air Quality
DoD: Department of Defense
DSS: decision support system
EE: exceptional event
EOS: Earth Observing System
EPA: Environmental Protection Agency
EPHTS: Environmental Public Health Tracking System
ESD: Earth Science Division
FAO: Food and Agriculture Organization of the United Nations
FRAPPÉ: Front Range Air Pollution and Photochemistry Éxperiment
GEO: Group on Earth Observations

GEOS-Chem: Goddard Earth Observing System–Chemistry
GFDL: Geophysical Fluid Dynamics Laboratory
GIBS: Global Imagery Browse Services
GIMMS: Global Inventory Modeling and Mapping Studies
GISS: Goddard Institute for Space Studies
GOES: Geostationary Operational Environmental Satellite
GPM: Global Precipitation Measurement
GSFC: Goddard Space Flight Center
HBM: hierarchical Bayesian model
HMS: Hazard Mapping System
IASI: Infrared Atmospheric Sounding Interferometer
I-HEAT: Internet-based Heat Evaluation and Assessment Tool
ISPRS: International Society for Photogrammetry and Remote Sensing
ITCT: Intercontinental Transport and Chemical Transformation
LANCE: Land Atmosphere Near real-time Capability for EOS
MATCH: Metadata Access Tool for Climate and Health
MERIS: MEdium Resolution Imaging Spectrometer
MI: myocardial infarction
MISR: Multi-angle Imaging SpectroRadiometer
MODIS: Moderate Resolution Imaging Spectroradiometer
MOPITT: Measurements of Pollution in the Troposphere
NAAPS: Navy Aerosol Analysis and Prediction System
NAB: North American Background
NASA: National Aeronautics and Space Administration
NCAR: National Center for Atmospheric Research
NDVI: Normalized Difference Vegetation Index
NEI: National Emissions Inventory
NESDIS: National Environmental Satellite, Data, and Information Service
NIH: National Institutes of Health
NLDAS: North American Land Data Assimilation System
NOAA: National Oceanic and Atmospheric Administration
OMI: Ozone Monitoring Instrument
OSTP: Office of Science and Technology Policy
PAR: Photosynthetic Active Radiation
PI: principal investigator
PM2.5: fine particulate matter
PREAM: Pollen REgional Atmospheric Model
RAQMS: Real-time Air Quality Modeling System
RSIG: Remote Sensing Information Gateway
SBA: Societal Benefit Area
SEAC4RS: Studies of Emissions, Atmospheric Composition, Clouds and Climate Coupling by Regional Surveys
SIP: State Implementation Plan
SMAP: Soil Moisture Active Passive
SPoRT: Short-term Prediction Research and Transition
SRTM: Shuttle Radar Topography Mission

TAD: Toolset for Airborne Data
TCEQ: Texas Commission on Environmental Quality
TEMPO: Tropospheric Emissions: Monitoring of Pollution
TES: Tropospheric Emission Spectrometer
TRMM: Tropical Rainfall Measuring Mission
UAH: University of Alabama in Huntsville
USFS: United States Forest Service
USGCRP: U.S. Global Change Research Program
USGEO: U.S. Group on Earth Observations
USRA: Universities Space Research Association
VIIRS: Visible Infrared Imaging Radiometer Suite
WHO: World Health Organization
WNV: West Nile virus
WRF: Weather Research and Forecasting
WRF-AERMOD: Weather Research and Forecasting–American Meteorological Society/Environmental Protection Agency Regulatory Model
WRF-Chem: Weather Research and Forecasting–Chemistry

NASA Applied Sciences Program
Health & Air Quality Applications Area

Program Manager
John Haynes
jhaynes@nasa.gov

Associate Program Managers
Sue Estes
sue.m.estes@nasa.gov

Ali Omar
ali.h.omar@nasa.gov